



Floristics of bryophytes in Dongbaek-dongsan at Seonheul Gotjawal

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선혈 꽃자왈 동백동산의 선태식물상 연구

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ABSTRACT: This study presents a survey on the bryophytes in Dongbaek-dongsan located at Seonheul Gotjawal on the north-eastern face of Mt. Halla in Jeju Island, Korea. A total of 85 taxa belonging to the Bryophyta (22 families 44 genera 62 species), Marchantiophyta (12 families 16 genera 23 species) were found. Among them, 3 moss species, *Diphyscium perminutum* Takaki, *Racomitrium japonicum* Dozy & Molk., and *Isopterygium minutirameum* (Müll. Hal.) A. Jaeger. were new additions to the bryophyte flora of Korea. The liverwort index was 27.0%. Predominant life-form was weft. The rates for the bryophytes dominating in mesic to hygric sites were higher than for the bryophytes mainly observed in xeric habitats. We considered that the composition and distribution of species are affected by the different environmental factors according to the evergreen broad-leaved forests, wetlands and exposed spaces. Moreover, the rocks were the substrate type that play a major role in providing the micro-habitats for bryophytes in this area. Particularly, the bryophytes of swamps in this area were very unique and various for its limited space and showed plant communities with mosaic spatial pattern, along with vascular plants. We suggest more detailed and comprehensive studies on the swamps where endemic fern *Mankyua chejuense* B. -Y. Sun, M. H. Kim & C. H. Kim inhabits to provide valuable information for the conservation and restoration of the species and habitats.

Keywords: Bryophyte flora, unrecorded moss, Gotjawal, liverwort index, life-form

적 요: 본 연구는 제주도 한라산 북동사면의 선혈 꽃자왈에 위치하고 있는 동백동산의 선태식물을 대상으로 하였다. 식물상 조사 결과, 선류는 22 과 44 속 62 종, 태류는 12 과 16 속 23 종으로 총 85 종이 확인되었다. 이 중 *Diphyscium perminutum* Takaki, *Racomitrium japonicum* Dozy & Molk., 그리고 *Isopterygium minutirameum* (Müll. Hal.) A. Jaeger.는 한국미기록식물에 해당하여 본 연구를 통해 기재하였다. 태류지수는 27.0%이고, 식물형의 생활형에 해당하는 선태식물이 가장 많이 분포하는 것으로 나타났다. 또한 중습성 또는 습성의 환경에 주로 생육하는 선태식물의 비율이 건조한 환경에서 주로 출현하는 선태식물의 비율보다 높았다. 본 연구를 통해 조사지 내의 상록활엽수림, 습지, 나지 등에 의한 다양한 환경 요인이 종의 구성과 분포에 영향을 미치고 있는 것으로 파악되었다. 그리고 이 지역에서 암석은 선태식물에 미소환경을 제공하는 데 있어 주요한 요인으로 작용하는 기질이였다. 특히, 동백동산의 소택지에 분포하는 선태식물은 면적에 비해 독특하고 다양하며, 관속식물과 함께 모자이크 공간 유형의 식물군락을 이루는 것으로 나타났다. 아울러 제주고사리삼과 자생지의 보존과 복원을 위한 기초 자료를 제공할 수 있도록 한국 고유 양치식물인 제주고사리삼이 자생하는 소택지를 대상으로 한 보다 정밀하고 종합적인 조사를 제안하는 바이다.

주요어: 선태식물상, 미기록선류, 꽃자왈, 태류지수, 생활형

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Dongbaek-dongsan is located at Seonheul Gotjawal on the north-eastern face of Mt. Halla in Jeju Island, Korea. This area is comprised of the evergreen broad-leaved forests dominated by *Quercus glauca* Thunb. and *Castanopsis sieboldii* (Makino) Hatus, which is the largest on the plains in Jeju Island with an area of approximately 1.42 km². In addition, there are different sizes of wetlands including shallow open waters, marshes and swamps within or near the evergreen broad-leaved forests. The flora of vascular plants in Dongbaek-dongsan is diverse and unique. It is reported that a total of 73 families 138 genera 166 taxa inhabit Dongbaek-dongsan and the flora of vascular plants in this area is diverse and unique (Kim & Song, 2005). Especially, *Mankyua chejuense* B. -Y. Sun, M. H. Kim & C. H. Kim, a fern endemic to Korea was found on the swamps and described (Sun et al., 2001). For these reasons, this area has been considered to be very important from a botanical point of view. This area has been designated and protected as the local cultural properties No. 10 by Jeju Special Self-Governing Province, a Wetland Protection Area by the Ministry of Environment, Republic of Korea, and a Ramsar site by the Ramsar Convention.

The vascular flora and vegetation of Dongbaek-dongsan, as stated above, were well studied. However, only a few studies on the bryophytes have been conducted to date. Moreover, it is known that the bryophyte layers are well-developed and diverse in swamps, where *Mankyua chejuense* naturally inhabits (Kim, 2006), whereas the studies on bryophyte layers have not yet been sufficiently performed.

This study aims to provide a comprehensive bryophyte flora of Dongbaek-dongsan and contribute to the bryophyte flora of Gotjawal, Jeju Island and Korea on a regional scale.

Materials and Methods

Field surveys were carried out from November 2005 to April 2013 in Dongbaek-dongsan (Fig. 1). The samples collected in the investigation area were identified at species level with macroscopic morphology and microscopic features using relevant literatures (Institute of Botany, Chinese Academy of Sciences, 1972; Iwatsuki & Mizutani, 1972; Inoue, 1974, 1976, 1986; Choe, 1980; Noguchi, 1987, 1988, 1989, 1991, 1994; Kim & Hwang, 1991; Hwang, 1991; Gao et al., 1999; Makino, 2000; Iwatsuki, 2001; Li et al., 2001; Wu et al., 2002; Cao et al., 2003; Smith, 2004). We also examined the specimens deposited in Makino Herbarium in order to identify *Diphyscium perminutum*, an unrecorded species in Korea. All specimens were deposited in the herbarium at the Faculty of Environmental Studies of Nagasaki University (NU) in Japan

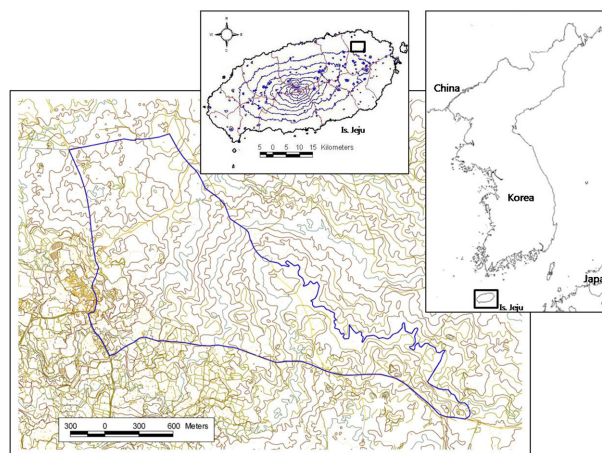


Fig. 1. The location of Dongbaek-dongsan, Jeju Island, Korea.

and Department of Life Science of Chonbuk National University (JNU) in Korea.

Nomenclature and arrangement of taxa in the list follows the system which is proposed by Iwatsuki (2001, 2004) for the mosses, Crandall-Stotler et al. (2009) and Renzaglia et al. (2009) with some modifications according to Konstantinova et al. (2009) and Yamada & Iwatsuki (2006) for the liverworts. Species new to Korean Peninsula were indicated with an asterisks (*) on the floristic list and described. The life-forms of bryophytes in the study area have been assessed using Mägdefrau (1982) and they are also given in the floristic list for each taxon. The records of habitats and substrates for each taxon were included in this list. In this paper, only one collection numbers for each taxon were cited to avoid repetition.

We compared the number of taxa and liverwort index of Dongbaek-dongsan with other localities based on revealed literatures [i. e., Mt. Deogyu (Choi et al., 2010; Yoon et al., 2011), Mt. Taebaek (Papp, 2008), Mt. Gwanak (Hong, 1960a), Mt. Soyo (Hong, 1960b)]. The liverwort index, which is based on the character that the liverworts and hornworts tend to prefer more humid conditions than mosses, was calculated as follow (Nakanishi, 2001):

$$\text{Liverwort index (\%)} = \frac{\text{No. of liverworts} + \text{No. of hornworts}}{\text{The total number of bryophytes}} \times 100$$

Results and Discussion

The number of taxa and liverwort index

In this study, a total of 85 taxa belonging to the Bryophyta (22 families 44 genera 62 species), Marchantiophyta (12 families 16 genera 23 species) were determined (Appendix 1). The comparison result for the number of taxa in Dongbaek-

Table 1. Comparison to the liverwort index of Dongbaek-dongsan and other localities.

Locality	Altitude (m)	Area (km ²)	No. of mosses	No. of liverworts & hornworts	The total no. of bryophytes	Liverworts index
Mt. Deogyu	1,614	232.000	184	127	311	40.8
Mt. Gwanak	629	19.220	64	14	78	17.9
Mt. Taebaek	1,567	17.440	102	42	144	29.2
Mt. Soyo	587	2.472	68	11	79	13.9
Dongbaek-dongsan	147	1.420	62	23	85	27.0

dongsan, Mt. Deogyu, Mt. Gwanak, Mt. Taebaek and Mt. Soyo presented that Dongbaek-dongsan contained rich diversity of bryophytes for the area (Table 1).

The liverwort index of Dongbaek-dongsan was 27.0%. This value indicates that the air humidity of investigated area was relatively lower than Mt. Deogyu and Mt. Taebaek but higher than Mt. Gwanak and Mt. Soyo. This result was unrelated to altitude (Table 1).

Newly recorded species to bryophyte flora of Korea

3 moss species *Diphyscium perminutum* Takaki, *Racomitrium japonicum* Dozy & Molk., and *Isopterygium minutirameum* (Müll. Hal.) A. Jaeger. collected from Dongbaek-dongsan, are new additions to the bryophyte flora of Korea (Appendix 1, Fig. 2). The descriptions of these 3 taxa are as follows.



Fig. 2. Newly recorded species for the Korean flora. A. *Diphyscium perminutum* Takaki a. plant. b. leaf. c. median leaf cells; B. *Racomitrium japonicum* Dozy & Molk. d. plants. e. leaves. f. cross-sections of leaves; C. *Isopterygium minutirameum* (Müll. Hal.) A. Jaeger. g. plants. h. leaf. i. pseudoparaphylla.

1. *Diphyscium perminutum* Takaki, J. Jpn. Bot. 25: 185, f. 6. 1950.

Korean name: Ae-gi-bo-ri-al-i-kki **애기보리알이끼**

Plants small, 3.5-4.1 mm, dark-green. **Stems** very short. **Leaves** few, 0.7-2.1 mm; lower leaves linear, obtuse; upper leaves linear, wider at the base, apex acute; costa stout, ending below leaf apex; median cells rounded to rounded-hexagonal, 7.5-12 μ m, mammillose, walls \pm incrassate at the corners, upper cells similar to the medians; lower cells rectangular, with thin walls. **Diocious**. Perichaetial leaves numerous; outer leaves oblong, acute at apex, awn scabrous, 2.7-4.1 mm; inner leaves acute with many long cilia on the upper half of leaf margins, \pm awn flexuose, crenulate, 1.8-2.5 mm. Capsules ca. 2 \times 1 mm, ovoid, stomata present. Opercula long- conic, blunt at apex. Endostomes ca. 0.5 mm long.

Distribution: Korea (Jeju: Dongbaek-dongsan), Japan.

D. perminutum was reported as an indigenous species of Japan and ranked as category I of rare and endangered species by the Ministry of Environment of Japan (Iwatsuki, 2001).

This species is similar to *D. fulvifolium* Mitt, which is distributed in Korea including Birobong, Gongju, Hamheungn, Jeju Island, Mt. Daedun, Mt. Geumgang, Nogodan, Songheung-ri, Tongcheon (Choe, 1980; Hwang, 1991), since it has perichaetial leaves with many ciliate appendages. The former, however, can be clearly distinguished from latter because of small size, gradual tapering leaves, shorter costa (which ends below leaf apex), and rounded or rounded-hexagonal mammillose median-leaf cells.

New Korean name is given as 'Ae-gi-bo-ri-al-i-kki', based on plant size.

2. *Racomitrium japonicum* Dozy & Molk., Musci Frond. Ined. Archip. Indici 5: 130, f. 41. 1847. *Grimmia japonica* (Doz. et Molk.) Mitt., Trans. Linn. Soc. London Bot. ser. 2, 3: 158. 1891. *Niphotrichum japonicum* (Dozy & Molk.) Bednarek-Ochyra & Ochyra in Ochyra, Zarnowiec &

Bednarek-Ochyra, Cens. Cat. Polish Mosses: 138. 2003. *Racomitrium iwasakii* Okam., J. Coll. SC. Imp. Univ. Tokyo 38: 13. 6. 1916. *Racomitrium canescens* (Hedw.) Brid. var. *iwasakii* (Okam.) Ihs., Cato Moss. Japan 79. 1929. *Racomitrium barbulooides* Card. var. *brevipilum* Dix., Rev. Bryol. Lich. 7: 107. 1934. *Racomitrium canescens* (Hedw.) Brid. for. *viridisenile* Sak., Bot. Mag. Tokyo 51: 794. 1937. *Racomitrium szuchuanicum* P. C. Chen, Contr. Inst. Biol. Natl. Centr. Univ. 1: 4. 1943. *Racomitrium canescens* (Hedw.) Brid. var. *viridisenile* (Sak.) Sak., Musci Jap. 64. 1954.

Korean name: Neuj-eun-seo-ri-i-kki 늦은서리이끼

Plants stiff, sometimes stout, (1) 2-5 (6) cm long, green or yellowish above, brownish below, usually in loose patches. **Stems** erect, simple or sparsely branched; central strand absent. **Leaves** imbricately appressed, somewhat contorted or spirally arranged when dry, erect-spreading when moist, often reflexed, oblong-ovate, 2.0-2.5 mm × 0.7-1.0 mm, suddenly narrowed to dentate, acuminate apices, often keeled above, somewhat undulate or plicate below, with very short, not papillose hyaline hair-points, sometimes hair-points absent; margins recurved on both sides, unistratose in cross section; costa rather stout, extending to ca. 4/5-5/6 the leaf length, ending below the apex; upper leaf cells rounded-quadrate to subquadrate, 5-7(-9) μm wide, sinuately thick-walled, with low papillae; median cells short-rectangular, 9-12 μm × 5-7 μm, strongly sinuately thick-walled, with high papillae; alar cells distinctly differentiated, yellowish, consisting of a group of 20 inflated cells, 34-53 × 16-23, straight-walled, smooth. **Dioicous**. Setae erect, reddish brown, ca. 3-15 mm long. Capsules erect, reddish brown, oblong-ovoid, ca. 2-5 mm long. Opercula obliquely long-rostrate. Peristome teeth linear; divided to the base, reddish brown, 0.7-1.0 mm long densely papillose. Spores 7-10 μm.

Distribution: Korea (Jeju: Dongbaek-dongsan), Japan, China, Vietnam, Russia, Australia.

R. japonicum is similar to *R. canescens* var. *latifolium* (C. Jens. in J. Lange & C. Jens.) Frisvoll (Seo-ri-i-kki, 서리이끼), which was recognized as *R. canescens* (Hedw.) Brid. in Japan as well as in Korea and is distributed across Korea. In Japan and China, *R. japonicum* is often misidentified as *R. canescens* var. *latifolium* (Cao et al., 2003). In addition, the length of costa, a main taxonomic characteristic between these species was described inconsistently in the literatures of Korea, Japan, and China (Institute of Botany, Chinese Academy of Sciences, 1972; Choe, 1980; Inoue, 1986; Hwang, 1991; Cao et al., 2003). The former, however, can be distinguished from latter by longer costa and distinctly keeled leaves.

Some foreign botanists reported that *R. japonicum* was distributed in Korea, however, the localities were inexact. In addition, Korean name has not been reported until now (Cao et al., 2003; Frisvoll, 1983; Iwatsuki, 2001; Vitt et al., 1993). We chose, therefore, the Korean name 'Neuj-eun-seo-ri-i-kki' because this species has not established in Korea and the meaning of 'Neuj-eun' in Korean is 'late.'

3. *Isopterygium minutirameum* (Müll. Hal.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876-1877: 434 (Gen. Sp. Musc. 2: 1252). 1878. *Hypnum minutirameum* Müll. Hal., Syn. Musc. Frond. 2: 689. 1851. *Ectropothecium delicatulum* Thér. Diagn. Esp. Var. Nouv. Mouss, 8: 6. 1910. *Sematophyllum argenteum* Sakurai, Bot. Mag. Tokyo 64: 197. f. l. 1951.

Korean name: Geot-ju-mog-i-kki 겉주목이끼

Plants small, pale- or yellowish-green. **Stems** and branches similar, branches ascending, 1-1.5 mm wide with leaves, densely and ± complanately leaved. Pseudoparaphyllia filamentous. **Leaves** scarcely altered when dry, widely spreading, often homomalous-secund, lanceolate, slenderly tapering to a narrow acumen, 0.8-1.2 mm, concave; margin entire, erect; costa indistinct; median laminal cells linear, 80-90 × 4-5 μm, thin-walled; upper laminal cells ± wider; one or two rows of cells across leaf insertion oblong, shorter and wider; several cells at the basal angles rectangular or subquadrate but not forming distinct alar regions. **Autoicous**. Inner perichaetial leaves long- vaginate, acuminate, erect, to 1 mm long. Setae 11-14 mm long. Capsules inclined, oblong-cylindrical, with an apophysis, 0.9-1.3 × 0.5-0.6 mm. Opercula bluntly conic, ca. 0.5 mm long. Exostome teeth ca. 0.3 mm long. Spores 9-12 μm.

Distribution: Korea (Jeju: Dongbaek-dongsan), Japan (Hons-hu-Ryukyuu, Ogasawara), Australia.

I. minutirameum is similar to *I. albescens* (Hook.) A. Jaeger, since it has filamentous pseudoparaphyllia. The former characterized by pale- or yellowish-green color and laceolate leaves which are gradually tapering to an acuminate apex. The latter has whitish color and the ovate to ovate-oblong leaves which are abruptly tapering to a narrow elongate acumen.

The Korean name of this genus is Geot-ju-mog-i-kki-sog (Choe, 1980). However, any species which has the Korean name as Geot-ju-mog-i-kki has not yet been reported. Moreover, the Korean name of *I. albescens* is 'Huin-Geot-ju-mog-i-kki (흰겉주목이끼)' and the meaning of 'Huin' in Korean is 'white.' We chose, therefore, the Korean name 'Geot-ju-mog-i-kki' based on the color of the plants.

Life-forms

We assessed the life-forms for each taxon in the study area and presented in the Fig. 3. Predominant life-form among bryophytes in the study area was wefts (29.4 %), followed by mats (23.5 %), tall turfs (17.6 %), fans (12.9 %), short turfs (7.1 %), and annuals, cushions, dendroids, tails (2.4 %, each of them). We analyzed this result based on the relationship between the adaptive strategy and life-form of bryophytes according to Kürschner (2004), Uyar et al. (2007), and Glim (2013). As a result, the life-forms of wefts, mats, fans, tails and dendroids dominating in mesic to hygric sites were 70.6 %, whereas the

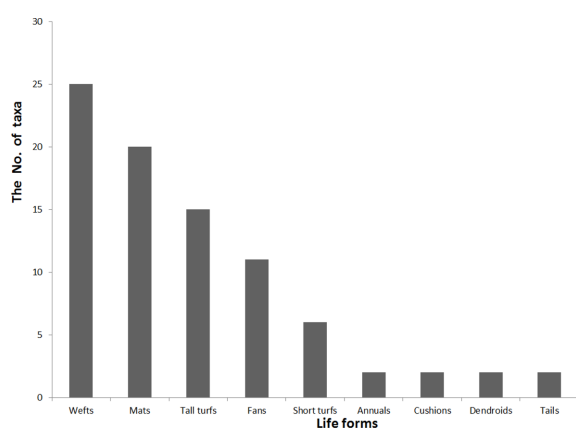


Fig. 3. Life forms spectrum of bryophytes in the study area.

life-forms of tall turfs, short turfs, annuals, and cushions mainly observed in xeric habitats were 29.4% (Appendix 1, Fig. 3). These values indicate that the evergreen broad-leaved forests and wet lands are almost widespread whole parts of the study area and have a major effect on bryophyte flora.

Distribution pattern

We assessed the habitat types and substrates for each taxon to investigate the distribution pattern. The number of taxa according to the habitat type and substrates are presented in the Table 2. In this study, the bryophytes do not exist in the shallow open waters and marshes. The number of taxa confirmed in the evergreen broad-leaved forests, swamps, and exposed spaces were 50, 46, and 24 respectively. The liverwort index was the highest in the swamps (32.6%), followed by the evergreen broad-leaved forests (22.0%) and open spaces (20.8%). In addition, the composition of species was different in each habitat type. It is considered that the distribution of bryophytes is affected by the different environmental factors including air humidity, light intensity etc. according to each habitat type. We think that these results correspond to the analysis result of life-form. Upon investigation into substrates, the bryophytes on the rock were most diverse as 54 taxa followed by bark (38 taxa), soil (23 taxa), and decayed wood (5 taxa). The result seems to be caused by that the various sizes of volcanic rock masses lay

Table 2. The number of taxa according to the habitat type and substrate in the study area.

Substrate	Habitat type	Specific to			Common to			Total
		Evergreen broad-leaved forest	Swamp	Exposed space	Evergreen broad-leaved forest & swamp	Evergreen broad-leaved forest & exposed space	All habitat types	
Specific to	Epilithic	12	6	1	3	2	1	25
	Epiphytic	5	8	-	3	-	-	16
	Epixylous	-	1	1	-	-	-	2
	Soil	2	-	9	-	2	-	13
Common to	Epilithic & epiphytic	2	5	-	9	-	-	17
	Epilithic & epixylous	-	-	-	-	-	1	1
	Epilithic & soil	-	-	3	1	-	1	6
	Epilithic, epiphytic & epixylous	-	-	-	1	-	2	1
	Epilithic, epiphytic & soil	-	1	-	2	-	-	3
	All substrates	-	-	-	-	-	1	1
	Total	21	21	14	19	4	6	85

scattered over the study area and offer a lot of micro-habitats for bryophytes due to one of the characteristics of Gotjawal.

The bryophytes of swamps

It is remarkable that the swamps in this area showed the very unique and various bryophytes. We confirmed 21 taxa of the bryophytes specific to the swamp, although the total area of swamps is remarkably smaller than the evergreen broad-leaved forests (Table 2). Among them, *Climacium dendroides* (Hedw.) F. Weber & Mohr., *Leskea polycarpa* Ehrh. ex Hedw., and *Entodon challengerii* (Paris) Cardot are the mosses which mainly inhabit the deciduous broad-leaved forests. We note that these taxa included a species of dendroid moss, *Climacium dendroides*, which was found on the rocks (covered with humus soil) and humus soil (Appendix 1). Since Glime (2013) referred to the fact that the mosses of these dendroid type would seem to be particularly vulnerable to desiccation, with only a single stem in contact with the substrate and many exposed branch. The bryophytes in the swamps showed the various sizes of communities with high density on the rocks, bark, decayed wood and humus soil (Fig. 4). We think that the characteristics of swamps in Dongbaek-dongsan are one of the reasons why the swamps contain very unique flora and vegetation. We confirmed that the swamps in this area are distributed in shallow depressions on the ground and the intermittent flooding and draining due to topographical and geological features occur there. We think that these characteristics can have an influence on adaptive strategy of bryophytes. In addition, the canopies of these wetlands are comprised of deciduous broad-leaved trees including *Ulmus parvifolia* Jacq. and *Cudrania tricuspidata* (Carriere) Bureau ex Lavallee etc. Based on Ohba (1991), we understand that the environmental conditions such as air humidity, light intensity, and temperature etc can be more



Fig. 4. A panoramic photo of swamp.

capricious, and the disintegration and accumulation of autumn leaves, humus soil, and decayed wood according to phenological events more likely to occur in the deciduous broad-leaved forests than evergreen forests. We agree with Hyeon (2011)'s results that the composition and life-forms of vascular plants in swamps are distinguished from surrounding area and these wetlands are isolated habitats in terms of vascular plant. We suggest that these view can be applied to the bryophytes, as well. In other words, the bryophytes of swamps in this area showed plant communities with mosaic spatial pattern, along with vascular plants. Meanwhile, the swamps in Dongbaek-dongsan, as stated above, are where the endemic fern *Mankyua chejuense* inhabits. Sun et al. (2001) reported this fern for the first time and placed it in the monotypic genus *Mankyua*, which shares peculiar morphological characteristics with *Ophioglossum* s.l. and *Helminthostachys* (Ophioglossaceae). After that, molecular phylogenetic analysis indicated that *M. chejuense* is more closely related to the species of the genus *Botrychium* than to other genera in the family Ophioglossaceae (Sun et al., 2002, 2009). In addition, it was suggested that this genus might be the earliest-diverging lineage of Ophioglossaceae based on the chromosome number and phylogenetic position (Shinohara et al., 2013). Therefore, it is not too much to say that the discovery of *M. chejuense* unties the groups within Ophioglossaceae. This fern was also discussed in terms of the scientific values, rarity, danger of extinction, and conservation. This species has been ranked as category II of endangered species by the Ministry of Environment, Republic of Korea and considered as an appropriate species to The World Conservation (IUCN) Red data (IUCN, 2001; Kim, 2004; Chang et al., 2005; Republic of Korea: the Ministry of Environment, 2005; Kim, 2006). Recent research suggested *in situ* protection of habitats of standing populations and *ex situ* preservation of several populations for the development of conservation strategies for *M. chejuense* because the extremely low levels of genetic diversity in *M. chejuense* would be attributable to inbreeding coupled with random genetic drift and rarity (Chung et al., 2010). Although it was recently reported that this fern inhabits Gimnyeong-ri Myosanbong and Dongbok-ri which are the surrounding area of Dongbaek-dongsan, this species remains specific to the north-eastern area of the Jeju Island in the world (Kim, 2006; Hyeon, 2011). We suggest more detailed and comprehensive studies on environmental conditions of the swamps in Dongbaek-dongsan as well as Gimnyeong-ri Myosanbong and Dongbok-ri where *Mankyua chejuense* inhabits and ecological characteristics of the bryophytes should be conducted to provide valuable information for the conservation and restoration of the *M. chejuense*.

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Appendix 1. Floristic list of Dongbaeck-dongsan in Korea.

The Korean name and life-form are provided. The asterisks (*) are species new to Korean flora. The abbreviations of the habitat types and substrates are following: Ev: in the evergreen broad-leaved forest, Sw: in the swamp, Ex: in the exposed space, L: epilithic, P: epiphytic, X: epixylous, S: on the soil.

BRYOPHYTA Schimp. 선류식물문

DIPHYSICIACEAE Schwägr. 보리알이끼과

- *1. *Diphyscium perminutum* Takaki 애기보리알이끼 (국명 신칭) Annuals; Ev-P; *Yim, E. Y. 403* (NU)

POLYTRICHACEAE Schwägr. 솔이끼과

2. *Atrichum undulatum* var. *gracilisetum* Besch. 넓은주름솔이끼 Tall turfs; Ex-S; *Yim, E. Y. 890* (NU)
3. *Pogonatum neesii* (Müll. Hal.) Dozy 들솔이끼 Tall turfs; Ex-S; *Yim, E. Y. 788* (NU)

FISSIDENTACEAE Schimp. 봉황이끼과

4. *Fissidens dubius* P. Beauv. 벼슬봉황이끼 Tall turfs; EvSw-LPS; *Yim, E. Y. 636* (NU)
5. *Fissidens nobilis* Griff. 봉황이끼 Tall turfs; EvSw-LS; *Yim, E. Y. 666* (NU)
6. *Fissidens teysmannianus* Dozy & Molk. 아기봉황이끼 Tall turfs; Ex-S; *Yim, E. Y. 654* (NU)

DITRICHACEAE Limpr. 금실이끼과

7. *Ditrichum pallidum* (Hedw.) Hampe 금실이끼 Short turfs; Ex-S; *Yim, E. Y. 380* (NU)
8. *Trematodon longicollis* Michx. 두루미이끼 Tall turfs; Ex-S; *Yim, E. Y. 383* (NU)

LEUCOBRYACEAE Schimp. 흰털이끼과

9. *Leucobryum juniperoideum* (Brid.) Müll. Hal. 가는흰털이끼 Tall turfs; Sw-X; *Yim, E. Y. GPS25-1* (NU)

POTTIACEAE Schimp. 침꼬마이끼과

10. *Weissia controversa* Hedw. 꼬마이끼 Short turfs; Ex-LS; *Yim, E. Y. 142* (NU)

GRIMMIACEAE Arn. 고깔바위이끼과

11. *Ptychomitrium linearifolium* Reimers 돌주름곱슬이끼 Cushions; Ex-S; *Yim, E. Y. 648* (NU)
12. *Ptychomitrium sinense* (Mitt.) A. Jaeger 곱슬이끼 Cushions; Ex-S; *Yim, E. Y. 675* (NU)

- *13. *Racomitrium japonicum* Dozy & Molk. 늦은서리이끼 (국명 신칭) Tall turfs; Ex-LS; *Yim, E. Y. 379* (NU)

ERPODIACEAE Broth. 나무연지이끼과

14. *Glyphomitrium humillimum* (Mitt.) Cardot 깍지이끼 Short turfs; EvSw-P; *YJ 10251* (JNU)

BRYACEAE Schwägr. 참이끼과

15. *Brachymenium nepalense* Hook. 노란참외이끼 Short turfs; Ex-S; *Yim, E. Y. 791* (NU)
16. *Bryum argenteum* Hedw. 은이끼 Short turfs; Ex-S; *Yim, E. Y. 804* (NU)
17. *Rosulabryum capillare* (Hedw.) J.R.Spence 철사이끼 Short turfs; EvSw-LP; *YJ 10250* (JNU)

MNIACEAE Schwägr. 초롱이끼과

18. *Plagiomnium acutum* (Lindb.) T.J. Kop. 아기들덩굴초롱이끼 Tall turfs; EvSwEx-LS; *Yim, E. Y. 876* (NU)
19. *Plagiomnium vesicatum* (Besch.) T. J. Kop. 큰잎덩굴초롱이끼 Tall turfs; Sw-L; *Yim, E. Y. 20111128F9* (NU)
20. *Trachycystis microphylla* (Dozy & Molk.) Lindb. 아기초롱이끼 Tall turfs; Sw-L; *Yim, E. Y. 626* (NU)

CLIMACIACEAE Kindb. 나무이끼과

21. *Climacium dendroides* (Hedw.) F. Weber & Mohr 끈은 나무이끼 Dendroids; Sw-LPS; *Yim, E. Y. 640* (NU)

HEDWIGIACEAE Schimp. 툇이끼과

22. *Hedwigia ciliata* (Hedw.) Ehrh. ex P. Beauv. 툇이끼 Tall turfs; EvSwEx-L; *Yim, E. Y. 679* (NU)

CRYPHAEACEAE Schimp. 방울이끼과

23. *Forsstroemia cryphaeoides* Cardot 가는실방울이끼 Fans; EvSw-LP; *Yim, E. Y. 20111128F10* (NU)
24. *Forsstroemia trichomitria* (Hedw.) Lindb. 방울이끼 Fans; Sw-P; *Yim, E. Y. 800* (NU)

NECKERACEAE Schimp. 납작이끼과

25. *Homaliodendron flabellatum* (Sm.) M. Fleisch. 나무꼴 납작이끼 Dendroids; Ev-L; 2081 (NU)
26. *Neckera humilis* Mitt. 아기납작이끼 Fans; Ev-P; *Yim, E. Y. 698* (NU)
27. *Neckera pusilla* Mitt. 윤아기납작이끼 Fans; Ev-P; *Yim, E. Y. 888* (NU)
28. *Neckeropsis nitidula* (Mitt.) M. Fleisch. 리본납작이끼 Fans; EvSw-LP; *Yim, E. Y. 883* (NU)
29. *Thamnobryum plicatulum* (Sande Lac.) Z. Iwats. 그늘대호꼬리이끼 Fans; Ev-LP; *Yim, E. Y. 665* (NU)

30. *Thamnobryum subseriatum* (Mitt. ex Sande Lac.) B.C. Tan 대호꼬리이끼 Fans; EvSw-L; *Yim, E. Y.* 785 (NU)
- LEMBOPHYLLACEAE Broth. 호랑꼬리이끼과
31. *Dolichomitriopsis diversiformis* (Mitt.) Nog. 겉호랑꼬리이끼 Fans; Ev-L; *Yim, E. Y.* X4-3 (NU)
- LESKEACEAE Schimp. 고깔검정이끼과
32. *Leskea polycarpa* Ehrh. ex Hedw. 고깔검정이끼 Wefts; Sw-LP; *YJ 10247* (JNU)
33. *Orthoamblystegium spuriosubtile* (Broth. & Paris) Kanda & Nog. 선버들이끼 Wefts; Ev-LP; *SH1623* (JNU)
- THUIDIACEAE Schimp. 깃털이끼과
34. *Haplocladium angustifolium* (Hampe & Müll. Hal.) Broth. 침작은명주실이끼 Wefts; EvSwEx-LPXS; *Yim, E. Y.* 646 (NU)
35. *Haplocladium microphyllum* (Hedw.) Broth. 작은명주실이끼 Wefts; Ev-L; *Yim, E. Y.* GPS43 (NU)
36. *Haplohymenium sieboldii* (Dozy & Molke.) Dozy & Molke. 깃털바위실이끼 Wefts; EvSw-P; *SH2080* (JNU)
37. *Haplohymenium triste* (Ces.) Kindb. 바위실이끼 Tails; EvSw-P; *Yim, E. Y.* 687 (NU)
38. *Herpetineuron toccoae* (Sull. & Lesq.) Cardot 나산이끼 Tails; Sw-LP; *Yim, E. Y.* 801 (NU)
39. *Pelekium versicolor* (Müll. Hal.) Touw 아기깃털이끼 Wefts; Ev-L; *Yim, E. Y.* 774 (NU)
40. *Thuidium kanedae* Sakurai 깃털이끼 Wefts; EvSw-LP; *Yim, E. Y.* 861 (NU)
41. *Thuidium subglaucinum* Cardot 큰푸른깃털이끼 Wefts; EvSw-LP; *Yim, E. Y.* 2066 (NU)
- BRACHYTHECIACEAE Schimp. 양털이끼과
42. *Brachythecium buchananii* (Hook.) A. Jaeger 긴양털이끼 Wefts; Ev-L; *Yim, E. Y.* 779 (NU)
43. *Brachythecium plumosum* (Hedw.) Bruch & Schimp. 날개양털이끼 Wefts; EvSw-L; *Yim, E. Y.* 669 (NU)
44. *Brachythecium populeum* (Hedw.) Bruch & Schimp. 양털이끼 Wefts; EvEx-L; *Yim, E. Y.* 677 (NU)
45. *Brachythecium salebrosum* (F. Weber & Mohr) Bruch & Schimp. 넓은잎양털이끼 Wefts; Ev-S; *Yim, E. Y.* 904 (NU)
46. *Cirriphyllum piliferum* (Hedw.) Grout 걸끈양털이끼 Wefts; Ev-L; *Yim, E. Y.* 776 (NU)
47. *Oxyrrhynchium savatieri* (Schimp. ex Besch.) Broth. 가늠부리이끼 Wefts; EvSw-L; *Yim, E. Y.* 2065 (NU)
48. *Rhynchostegium pallidifolium* (Mitt.) A. Jaeger 아기양털부리이끼 Wefts; EvSwEx-LX; *Yim, E. Y.* 780 (NU)
- ENTODONTACEAE Kindb. 윤이끼과
49. *Entodon challengerii* (Paris) Cardot 넓은잎윤이끼 Wefts; Sw-LP; *Yim, E. Y.* 799 (NU)
50. *Entodon flavescens* (Hook.) A. Jaeger 가지윤이끼 Wefts; Sw-LP; *Yim, E. Y.* 635 (NU)
51. *Entodon sullivantii* (Müll. Hal.) Lindb. 가는윤이끼 Wefts; EvSw-LPX; *Yim, E. Y.* 634 (NU)
- PLAGIOTHECIACEAE (Broth.) M. Fleisch. 산주목이끼과
52. *Plagiothecium euryphyllum* (Cardot et Thér.) Z. Iwats. 넓은잎산주목이끼 Mats; Sw-L; *Yim, E. Y.* 20100807F2-2 (NU)
53. *Plagiothecium nemorale* (Mitt.) A. Jaeger 산주목이끼 Mats; EvSw-LPS; *Yim, E. Y.* 664 (NU)
- SEMATOPHYLLACEAE Broth. 무성아실이끼과
54. *Pylaisiadelphina yokohamae* (Broth.) W. R. Buck 털거울이끼 Mats; Ev-L; *Yim, E. Y.* GPS38-2 (NU)
55. *Sematophyllum subhumile* (Müll. Hal.) M. Fleisch. 나무실이끼 (국명 신칭) Mats; Ex-X; *Yim, E. Y.* 656 (NU)
- HYPNACEAE Schimp. 털깃털이끼과
56. *Ctenidium hastile* (Mitt.) Lindb. 머리빛이끼 Wefts; Ev-L; *Yim, E. Y.* 778 (NU)
- HYPNACEAE Schimp. 털깃털이끼과
57. *Hypnum oldhamii* (Mitt.) A. Jaeger 가는털깃털이끼 Wefts; EvSw-LP; *Yim, E. Y.* 387 (NU)
58. *Hypnum plumaeforme* Wilson 털깃털이끼 Wefts; EvSwEx-LS; *Yim, E. Y.* 141 (NU)
59. *Hypnum sakuraii* (Sakurai) Ando 붉은털깃털이끼 Wefts; Ex-LS; *Yim, E. Y.* 378 (NU)
- *60. *Isopterygium minutirameum* (Müll. Hal.) A. Jaeger 걸주목이끼 (국명 신칭) Wefts; Ev-P; *Yim, E. Y.* 871 (NU)
61. *Pseudotaxiphyllum pohliaecarpum* (Sull. & Lesq.) Z. Iwats. 빨간걸주목이끼 Mats; Ev-S; *Yim, E. Y.* 697 (NU)
62. *Taxiphyllum taxirameum* (Mitt.) M. Fleisch. 주목이끼 Mats; Ev-L; *Yim, E. Y.* 869 (NU)
- MARCHANTIOPHYTA Stotler & Crand.-Stotl. 우산이끼문
- MARCHANTIACEAE Lindl. 우산이끼과
63. *Marchantia polymorpha* L. 우산이끼 Mats; EvEx-S; *Yim, E. Y.* 680 (NU)
- RICCIACEAE Rchb. 등근이끼과
64. *Riccia glauca* L. 밭등근이끼 Annuals; EvEx-S; *Yim, E. Y.* 693 (NU)

METZGERIACEAE H. Klinggr. 리본이끼과

65. *Metzgeria furcata* (L.) Dumort. 산리본이끼 Fans; Sw-L; Yim, E. Y. 2068 (NU)
 66. *Metzgeria lindbergii* Schiffn. 리본이끼 Fans; Sw-LP; Yim, E. Y. 20111022F8 (NU)

PORELLACEAE Cavers 세줄이끼과

67. *Porella spinulosa* (Steph.) S. Hatt. 잔가시세줄이끼 Mats; EvEx-L; Yim, E. Y. 900 (NU)
 68. *Porella ulophylla* (Steph.) S. Hatt. 주름세줄이끼 Wefts; EvSwEx-LP; Yim, E. Y. 901 (NU)
 69. *Porella vernicosa* Lindb. 가시세줄이끼 Fans; EvSw-LP; Yim, E. Y. 20100918F1-1 (NU)

FRULLANIACEAE Lorch 지네이끼과

70. *Frullania inflata* Gottsch. 물가지네이끼 Mats; Sw-P; S. S. Choi 120270 (JNU)
 71. *Frullania muscicola* Steph. 참지네이끼 Mats; Sw-P; S. S. Choi 120252 (JNU)

LEJEUNEACEAE Cavers 작은귀이끼과

72. *Cheilolejeunea obtusifolia* (S. Hatt.) S.Hatt. 아기사슬이끼 Mats; Ev-L; Yim, E. Y. 20100807F3-4 (NU)
 73. *Cololejeunea japonica* (Schiffn.) Mizut. 세모귀이끼 Mats; Sw-P; S.S. Choi 121138 (JNU)
 74. *Lejeunea japonica* Mitt. 작은귀이끼 Mats; Sw-P; S.S. Choi 120256 (JNU)
 75. *Trocholejeunea sandvicensis* (Gottsche) Mizut. 둥근귀이끼 Mats; Sw-P; Yim, E. Y. 639 (NU)

- PSEUDOLEPICOLEACEAE Fulford & J. Taylor 솔잎이끼과
 76. *Blepharostoma minus* Horik. 솔잎이끼 Mats; Sw-P; S. S. Choi 120255 (JNU)

LOPHOCOLEACEAE Vanden Berghen 두끝벼슬이끼과

77. *Heteroscyphus argutus* (Reinw., Blume. et Nees.) Schiffn. 아기비늘이끼 Mats; Ev-L; Yim, E. Y. 20100806F5-2 (NU)
 78. *Heteroscyphus coalitus* (Hook.) Schiffn. 큰비늘이끼 Mats; Ev-P; Yim, E. Y. GPS52-3 (NU)
 79. *Heteroscyphus planus* (Mitt.) Schiffn. 비늘이끼 Mats; EvSw-LP; Yim, E. Y. 784 (NU)
 80. *Lophocolea minor* Nees 아기두끝벼슬이끼 Mats; Sw-P; S. S. Choi 120285 (JNU)

PLAGIOCHILACEAE Müll.Frib. & Herzog 날개이끼과

81. *Plagiochila ovalifolia* Mitt. 둥근날개이끼 Tall turfs; Ev-L; Yim, E. Y. GPS52-2 (NU)
 82. *Plagiochila sciophylla* Nees in Lindenb. 아기날개이끼 Tall turfs; EvSw-LP; Yim, E. Y. 806 (NU)

CEPHALOZIELLACEAE Douin 걸계밭이끼과

83. *Cephaloziella spinicaulis* Douin 가시걸계밭이끼 Wefts; Ex-L; S. S. Choi 121131 (JNU)

SCAPANIACEAE Mig. 엄마이끼과

84. *Scapania integerrima* Steph. 들엄마이끼 Tall turfs; Sw-L; S. S. Choi 120264 (JNU)

CALYPOGEIACEAE 목걸이이끼과

85. *Calypogeia tosana* (Steph.) Steph. 들목걸이이끼 Mats; Sw-L; Yim, E. Y. 792 (NU)